Applying Modified Bradford's Law of Scattering to Identify Core Journals of Surgical Robotics

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ABSTRACT: *This research attempts to use Bradford's law to identify the most productive "Surgical Robotics" journals. Using the search terms "surgical robotics / robotic surgery / robot-assisted surgery," the PubMed database was searched for journals indexed under the publication form and data collected was analysed using R software, Biblioshiny method; 6897 publications from 772 journals dealing with surgical robotics were retrieved from January 2015 to June 2020. As per Bradford's rule, the journal distribution revealed the ration as 16:64: 692. With 25.41% of publications, the United States of America was the leading country to publish robotic surgery studies, followed by Italy (15.93%) and China (10.36 %). The "Journal of Robotic Surgery" described as the most productive journal involved in "Surgical Robotics" research publications. For the Bradford Multiplier (k) at 8.75, the dispersion of journal publications did not satisfy either the Bradford Scattering law or the Leimkuhler model in this analysis.*

Keywords: Surgical Robotics, Bradford Law, Leimkuhler Model, Scientific Productivity, Journal

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1. Introduction

For researchers to determine the number of core journals in any given field, Bradford's Law is a respectable guide. It states that journals briefly divided into three areas in a single area, each containing an equal selection of articles:

1) A core journal on the subject, quite a few in quantity, producing the most efficient note on the popular fraction of all articles,

2) A second (reasonably productive) area, containing the same wide range of articles as the main one, but with a higher number of journals, and 3) a third (least efficient) region, containing an equivalent wide range of articles as the second, but still with an extra number of journals (Wilkinson1972). Bradford developed his legislation, covering 326 journals in the area, while working on a geology bibliography. It also found that there were 429 papers in 9 journals, 59 had 499 articles, and 258 had 404 articles. Nine journals were therefore used to make a contribution of one-third, five times nine (or 45) posts, to provide the next common proportion, and twenty-five times five for the last one-third. As is already shown, Bradford's Law is not statistically accurate, but its miles are still unremarkably used as a thumb rule to be precise (Oluic and Vesna 1998). Bradford as 1 expressed this rule: n: n^2 (Bradford 1948). Here "n" is interpreted as the multiplier of Bradford. The law of Bradford notes that the data is neither distributed uniformly nor inherently concentrated in a single location. Alternatively,

usually distributed data, i.e. a large number of valid papers, can be concentrated in some journals at the same time as possible papers disseminated through a large number of journals. Bradford also provided a graphical model of the regulation: he drew a graph with several papers on the Y-axis and the log rank logarithm on the X-axis, and then, starting with an increasing curve and ending as a linear line at a certain point, he extracted the graph. Nevertheless, for his rules, Bradford no longer suggested a mathematical equation, which was investigated and challenged but later researched and described by Vickery (1948) and Brookes (1969).

1.1. Significance of Scientific Journals for Research Prospects

Scientific journals are a great way for the social world to share scientific observations, discoveries and inventions, and future scientific predictions. Articles published in peer-reviewed scientific journals are recognised by competent experts and are thus reliable instruments that researchers, policymakers and the general public can acknowledge as well. Journals include a strong collection of research papers that can be used in a very exciting area to understand the progress of science and generate ideas for further study. Therefore, academic journals encourage scholars to interact; form an idea for the event of future development and monitor new ideas in the field of science. (Jette 2018). Publishing in prestigious journals increases researchers' visibility and credibility and provides prospects for employment. Rallison (2015) emphasised that journals go beyond providing a means of contact and a permanent record while discussing the role of journals in technical advances. Subsequently, his thesis concluded that journal articles are the result of most studies and that the success and efficacy of the researcher are largely measured by the number of publications, as they appear to be. The results of the study showed that, after communication advances, academic journals are still seen as a very effective and reliable publishing method.

1.1. Surgical Robotics

The emergence of new technology has made further advances in limited access surgery possible since the turn of the 21st century. In 1985, robotic-assisted surgery was first shown to perform a neurosurgery procedure requiring delicate accuracy. In 1987, the initial robotic-assisted cholecystectomy performed with its production. (Samadi 2018). The most frequently reported advantage of robotic surgery is that it can provide reliable, minimally invasive surgery that can effectively limit the surgeon to a safe area. In fact, complex operations can be conducted by using lightweight snake-like arms to work in areas that are otherwise hard to access. Without pain, numerous and repetitive movements may be made and will compensate for the contraction of the liver, heartbeat or breathing. For physicians, patients and insurance companies, the benefits of minimally invasive surgery are increasingly widespread. Special purpose robots can be worked inside an x-ray or MR scanner's narrow bore. (Perez and Schwaitzberg 2019). The advantages include fewer complications, such as infection of the surgical site, decreased pain and loss of blood, faster healing, and less noticeable scars (Morris B 2005). Smart healthcare systems must remain well informed about the status of robotic surgery and its role in improving the quality of health care as it continues to extend its competitive edge in robotic surgery. The demand for robotic surgery is at an all-time high and continues to grow within the near future (Rosen et al 2011). The Robotics industry has progressed past its infancy and has proven itself to be a positive and sustainable breakthrough. Currently, articles on robotic surgery are published in diverse and vibrant surgical journals, and there may be unprecedented global enthusiasm for the use of robotics in surgical operations, but there is a gap within the literary assets to help increase this new phenomenon. (Patel *et al* 2007). The purpose of this article is to classify successful publications in the field of surgical robotics. Bradford law extended to the dataset comprising 772 articles, which emerged worldwide from 6897 publications derived from the PubMed database over the period from January 2015 to June 2020. The use of robotics in surgery is now largely based on multiple surgical specialties and could be extended over the next many years as new technical improvements and strategies increase the applicability of its use.

2. Previous Studies

Many studies have attempted to examine the importance of the Bradford Law in the dissemination of contributions in journals. Sadik Batcha (2017) assessed the volume of research carried out worldwide on robotic technology, their year-wise share of research to world literature in robotics, forms and language that they publish their results, the quantum of their publications in terms of yearly output involved in research in robotic technology, and extent of international collaboration. The applicability of Bradford's law did not, however, fit into the study's outcome. Venable et al (2015) were able to see the key reviews of neurosurgery and its subspecialties in another report, the use of Bradford's verbal control with four sector fashions. For the top 25 North American clinical neurosurgeons from each sub-speciality selected from the specified career h-index diagnoses from previous studies, unique research publications from 2009 to 2013 were evaluated. The formula of

Egghe and the conceptual understanding of the Bradford Regulation were used to identify detailed zones of citation density and to classify main publications for each subspecialty. The citation dataset did not comply with the rule of Bradford, however. Desai et al (2018) advanced bibliometric profiles for the leading academically active pediatrics surgeons in the United States in a related report. These profiles contained the full range of courses; the publications in which the doctors listed their papers and the description, along with the publications on which the sources were found, of all the articles referred to for the use of such surgeons. In order to become aware of the major Pediatric Surgery papers, Bradford's law on scattering has been updated. The writers, with the aid of pediatrics surgeons, analyzed 58,310 references (top 20 journals). The core journals for P= 3-10 fields were approved by Bradford's Rule, providing a high-quality correlation between expected and actual values (R2= 0.9996). Wardikar and Gudadhe (2013) applied Bradford law to data produced by doctoral theses in the field of library and information science submitted to Maharashtra universities between 1982 and 2010. They found that the dataset did not agree with Bradford's law. However, according to the Leimkuhler interpretation, the dataset observed the law. Likewise, a study undertaken by Ram and Paliwal (2014) with psoriasis literature issued between 1960 and 2009 showed that the dataset did not conform to Bradford regulation. In this analysis, however, the data were found to be consistent with the Leimkuhler formulation.

3. Objectives of the Study

- Identification of highest active journals in the area of surgical robotics studies;

- Checking whether or not the knowledge still meets Bradford's regulation and Leimkuhler process.

4. Methodology

A total of 772 journals containing 6897publications retrieved from PubMed Database, United States National Library of Medicine (https://www.nlm.nih.gov/) during the years January 2015 to June 2020, were arranged in descending order of productivity (Table 5.1). Data collected on 24th June 2020 and were analyzed using "R" Programming Language, Biblioshiny tool (Aria and Cuccurullo 2017). The study considered abstract, free full text and full-text journal articles, which focused on human research and published in "English" covering Medline, nursing and dental journals. The research viewed publications as items and journals as sources. The groups separated into three areas and evaluated with their subject contents to see whether they agree with the Bradford law, while the normal log value of the total set of journal ranks for plotting the graph was determined for checking the appropriateness of the graphic formulation. It is vivid from figure 4.1 the growth of publications were steadily increasing from the year 2015 with 8.73% (165) publications, and the year 2016 recorded 1458 (21.14%) contributions. While the year 2017 showed 1505 (21.82%) publications and reached its peak during the years 2018(23.43%) and 2019(22.49%) respectively.

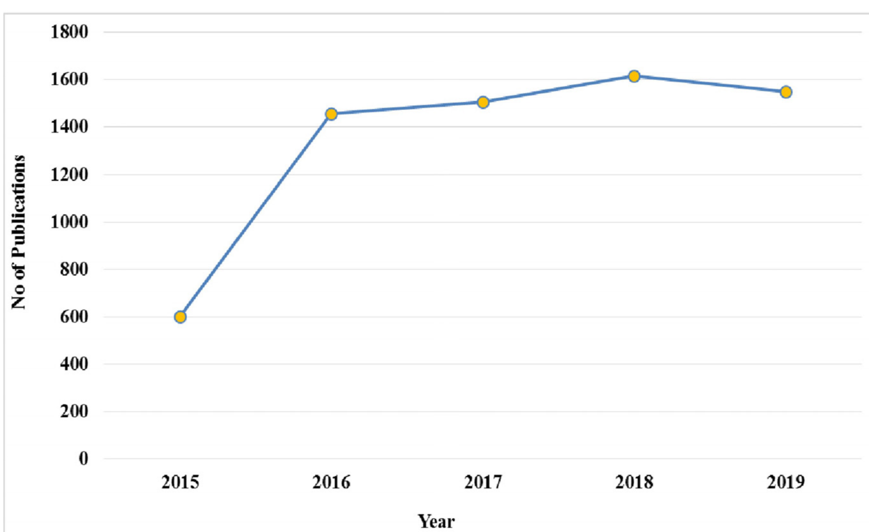

Figure 1. Growth of Publications in Surgical Robotics in the study period

5. Data Analysis and Discussion

5.1. Geographical Distribution of Journal Publications

As expressed by Tutarel (2002), the global distribution of publications as a measure of the quality of work by authors, nations, regions or institutions has emerged as an area of interest. The United States of America tops the list with 25.41% publications during the study period, followed by Italy (15.93%), China (10.36%), and South Korea (6.50). The following countries had contributed approximately 5% surgical robotics research worldwide - Japan (5.31%), France (5.15%), and Germany (5.10%). Less than 3% of contributions are made by countries including Canada (2.82%), Australia (2.75%) and Netherlands (2.34%). A smaller proportion of research contributions noted from countries like Turkey (1.72%), Belgium (1.64%), Spain (1.45%) and India (1.41%).

5.2. Most Contributed Papers

Some journals assume seminal positions in the field's development in any scientific field. Such papers, for their effects, are accelerating factors for the growth of the field. Figure 5.2 shows two clusters with the dimensions 1 corresponding to 75.03% variance and dimension 2 with 6.97% variance. In cluster 1(coded red) the publications viz. Cabras 2017, Tanaka S T 2019, Lefranc 2018, Li B 2017, Li B 2016, Ben Salem 2017 are found closely associated. In cluster 2 (coded blue) Kim S K, 2017, Zhang Y 2019, Yasin 2019, Belfiori G 2018 are seen related, while the publication canvasser 2016 found at distant proximity.

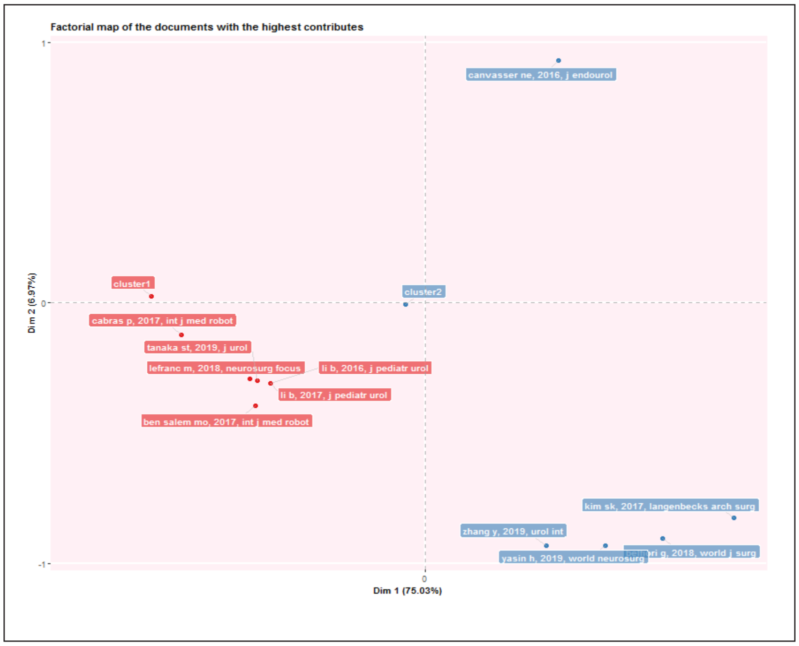

Figure 2. Most Contributed Papers

5.3. Multiple Correspondence Analysis (MCA)

Multiple correspondence analysis (MCA) is a correspondence analysis (CA) extension that enables one to examine the relationship patterns of many dependent categorical variables. Dimension one accounts for 29.19% variance and dimension two accounts for 21.26% variance. As such, when the variables to be evaluated are categorical instead of quantitative, it can also be seen as a generalization of principal component analysis (Abdi et al 2010). The factorial analysis derives two keyword classifications from (Figure 5.3). The classification in blue represents keywords like meta-analysis, systematic, review. The classification in red represents more specific keywords, like robotic-assisted, laparoscopic, carcinoma, receptor etc. The conceptual structure map is a factorial analysis of 6897 records, presenting a classification of common keywords from all data records, in two classifications.

5.4. Dendrogram on Trending Topics

Each leaf corresponds to one particular title in the dendrogram shown in Figure 5.4 for surgical robotics. Objects that are close to each other are merged into branches as we pass up the tree, which are fused at a higher height themselves. The vertical

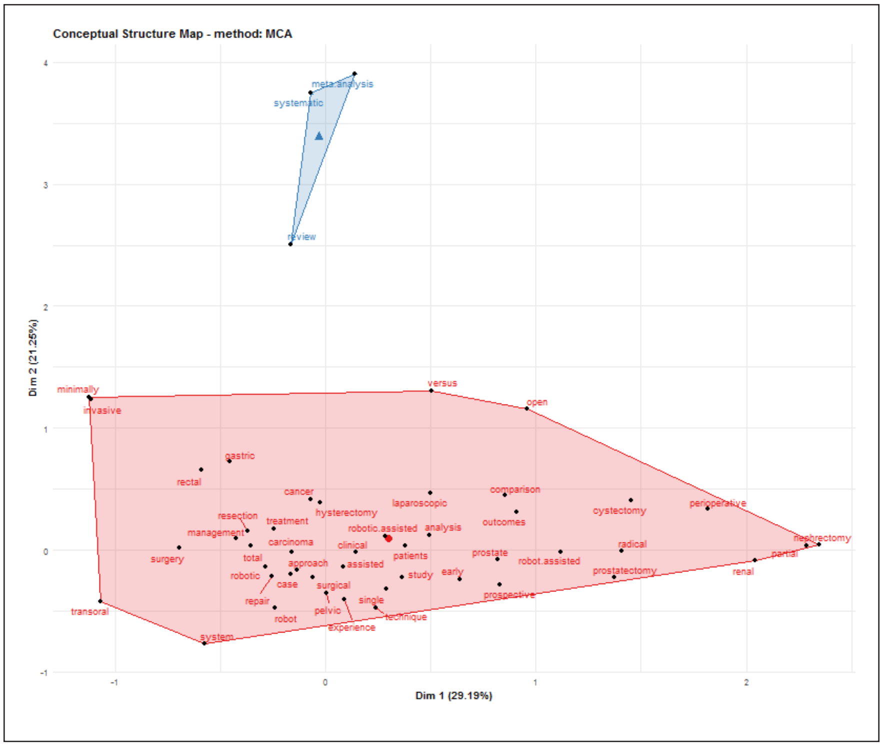

Figure 3. Conceptual Structure Map-Multiple Correspondence Analysis (Keywords)

axis height of the fusion shows the (dis)similarity/distance between two objects/clusters (Tomas et al, 2017). The higher the fusion height, the less alike the artefacts are. It should be noted that :

• The subjects' systemic and meta-analysis 'are strongly associated in cluster 1(blue)

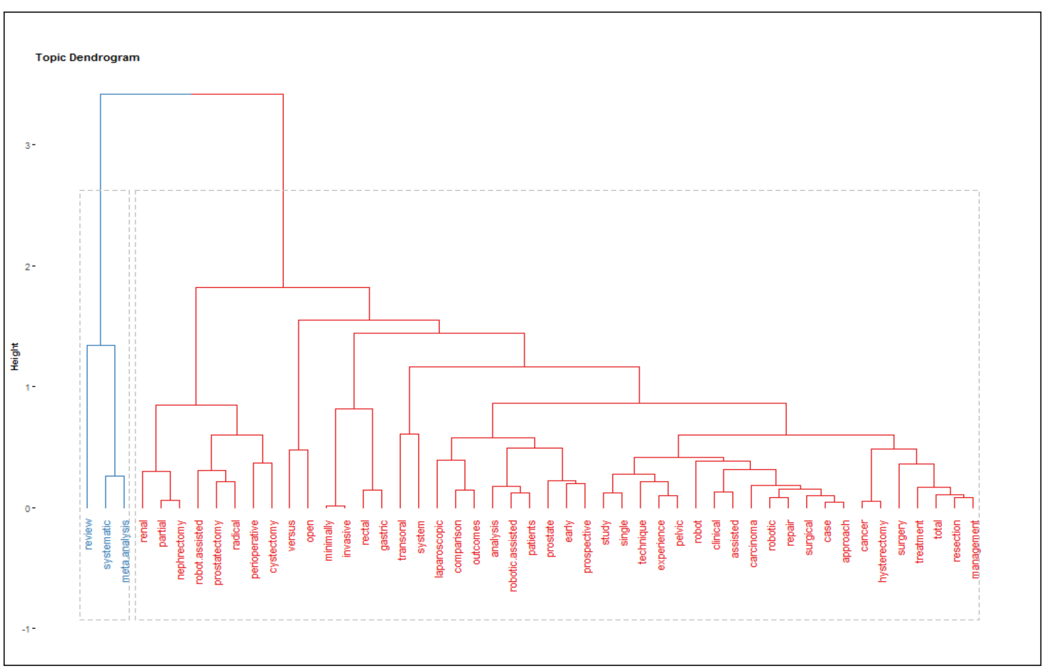

Figure 4. Dendrogram (Trending Topics)

• While the subjects' partial, nephrectomy',' prostatectomy, radical', perioperative, systectomy ',' minimally, intrusive ',' rectal, gastric ',' Clinical, assisted', 'resection, management' were found to be highly correlated in cluster 2(red)

• Whereas the topics 'review'(in cluster 1) and 'renal', 'robot-assisted', 'laparoscopic', 'robot' and 'surgery" of cluster 2 remained singleton.

5.5. Top Ranked Journals

It is well known that academics around the world are under pressure to publish in prestigious English journals. Journal ranking is a measure of the academic impact of scholarly journals, which accounts for both the number of citations obtained by the journal and, thus, the importance or reputation of the journals in which these citations originate. (Borja et al 2010). The rating criteria is purely quantitative, not qualitative. Table 5.5 presents the list of the top 50 robotic surgery publications. In the analysis, the 6897 publications are distributed in 772 journals. From the table, it is clear that "Journal of Robotic Surgery" (published from Springer by Society of Robotic Surgery) tops the list with 376 publications, followed by " Surgical Endoscopy" (published from Springer by Society of American Gastrointestinal and Endoscopic Surgeons and the European Association for Endoscopic Surgery) stands second and "The International Journal Of Medical Robotics and Computer Assisted Surgery" (published from John Wiley and Sons, the United Kingdom) occupies the third position with 236 publications.

S.No	Journals	Rank	Publications	Cumulative Publications	Zone
1	Journal of Robotic Surgery Surgical Endoscopy	1	376	376	I
2	The International Journal of Medical Robotics and Computer Assisted Surgery	2	299	675	I
3	Journal of Endourology Urology	3	236	911	I
4	Journal of Minimally Invasive Gynecology	4	163	1074	I
5	The Journal of Urology	5	163	1237	I
6	BJU International	6	138	1375	I
7	Journal of Laparoendoscopic & Advanced Surgical Techniques. Part A	7	137	1512	I
8	International Journal of Computer Assisted Radiology and Surgery	8	134	1646	I
9	World Journal of Urology	9	115	1761	I
10	European Urology	10	89	1850	I
11	Innovations (Philadelphia)	11	88	1938	I
12	Medicine	12	86	2024	I
13	Head & Neck	13	73	2097	I
14	Journal of Surgical Oncology	14	73	2170	I
15	The Annals of Thoracic Surgery	15	72	2242	I
16	Annals of Surgical Oncology	16	71	2313	I

17	The Annals of Thoracic Surgery	17	71	2384	II
18	Annals of Surgical Oncology	18	59	2443	II
19	Gynecologic Oncology	19	54	2497	II
20	The Italian Journal of Urology And Nephrology	20	54	2551	II
21	World Journal of Surgery	21	54	2605	II
22	Techniques in Coloproctology	22	53	2658	II
23	The Laryngoscope	23	51	2709	II
24	International Brazilian Journal Urology	24	49	2758	II
25	Journal of The Society of Laparoendoscopic Surgeons	25	49	2807	II
26	The American Surgeon	26	49	2856	II
27	Surgical Technology International	27	48	2904	II
28	Journal of Pediatric Urology	28	46	2950	II
29	International Journal of Urology	29	45	2995	II
30	World Neurosurgery	30	45	3040	II
31	Annals of Surgery	31	44	3084	II
32	Female Pelvic Medicine & Reconstructive Surgery	32	44	3128	II
33	Surgical Laparoscopy, Endoscopy & Percutaneous Techniques	33	44	3172	II
34	American Journal of Obstetrics and Gynecology	34	43	3215	II
35	Diseases of The Colon and Rectum	35	43	3258	II
36	International Journal of Surgery	36	43	3301	II
37	International Journal of Gynecological Cancer	37	42	3343	II
38	PLOS One	38	42	3385	II
39	Minerva Chirurgica	39	41	3426	II
40	Current Urology Reports	40	40	3466	II
41	European Journal of Surgical Oncology	41	40	3506	II
42	Urologic Oncology	42	40	3546	II
43	Updates in Surgery	43	38	3584	II

44	Surgical Innovation	44	37	3621	II
45	The Journal of Surgical Research	45	36	3657	II
46	International Journal of Colorectal Disease	46	35	3692	II
47	Current Opinion in Urology	47	34	3726	II
48	International Urogynecology Journal	48	34	3760	II
49	Journal of Gastrointestinal Surgery	49	33	3793	II
50	European Urology Focus	50	32	3825	II
51		51	32	3857	II
52		52-56	31X5	4012	II
53		57-58	30X2	4072	II
54		59-60	29X2	4130	II
55		61-62	28X2	4186	II
56		63	27	4213	II
57		64-66	26X3	4291	II
58		67-68	25X2	4341	II
59		69-71	24X3	4413	II
60		72-73	23X2	4459	II
61		74-77	21X4	4543	II
62		78-83	19X6	4657	II, III*
63		84-87	18X4	4729	III
64		88-92	17X5	4814	III
65		93-99	16X7	4926	III
66		100-104	15X5	5001	III
67		105	14	5015	III
68		106-110	13x5	5080	III
69		111-119	12X9	5188	III
70		120-131	11X12	5320	III

71		132-139	10X8	5400	III
72		140-150	9X11	5499	III
73		151-164	8X14	5611	III
74		165-177	7X13	5702	III
75		178-198	6X21	5828	III
76		199-226	5X28	5968	III
77		227-267	4X41	6132	III
78		268-344	3X77	6363	III
79		345-450	2X106	6575	III
80		451-772	1X322	6897	III

*Journal Rank -78 - 80 belong to zone II, with 19 publications each,

*Journal Rank- 81-83 belong to Zone III, with 19 publications each

Table 1. Journal Productivity in descending order

5.5.1. Applicability of Bradford's Law

To check the applicability of Bradford's rule to the dataset, the publications ($N = 6897$) were approximately divided into three zones, accounting for 2299 publications for each zone. To verify the algebraic definition of the law, 772 journal titles have been divided into three areas or zones. The Bradford multiplier shall be expressed as the ratio of the number of journals in any category to the number of journals in any immediately preceding category. (Girap et al, 2014). Since the error percentage in the distribution of publications should be smaller, they are divided into three zones. The distribution of journals and the corresponding number of publications within the three zones in addition to the Bradford multiplier value are shown in Table 5.5.1. In the data gathered, 16 journals covered 2313 papers, another 64 journals covered 2287 papers and a further 692 journals covered 2297 articles. In other terms, one-third of the total publications are covered by each category of journals. The ratio of each zone 1: n: n2 is 16:64:692. The Bradford multiplier average is 9.41. Bradford's law on current data is extended as 16:150.56:1416.77 and the percentage error found to be 105.09, which is technically wrong, indicating that the data does not comply with Bradford's law.

Zone	Journal Rank	Journal Rank %	Cumulative Publications	Cumulative Publications %	Bradford Multiplier
I	16 -	2.07	2313	33.54	-
II	64	8.29	2287	33.16	4
III	692	89.64	2297	33.30	10.81
Total	772	100.00	6897	100.00	9.41

Table 3. Bradford Multiplier Based on the Journal Rank

n = 9.41, Therefore 1: n: n^2

= 1X16:16X (9.41):16X $(9.41)^2$

= 16:150.56:1416.77>1583.33

$$Error\,\% = \frac{1583.33-772}{772} \text{ X } 100 = 105.09$$

Hence, Leimkuhler model (1967) is used for the verification of Bradford's law of Scattering.

5.5.2. Leimkuhler Model

$R(r) = a\ log(1 + br)$

Where r = 1, 2, 3 ....

Egghe (1990) explained the Leimkuhler model as:

$a = Y_0 / \log k$

$b = k - 1/r_0$

Here r_0 - is the number of articles in the first Bradford zone

Y_0 – the number of articles in every Bradford zone (all these articles of equal sizes), and

k – The Bradford multiplier

$R(r)$ is the cumulative number of journals produced by journal rank 1, 2, 3…. r

a and b are constants appearing in the law of Leimkuhler (1980). Egghe (1990) has shown the mathematical formula for calculating the Bradford Multiplier k as

Step 1: $k = (e^{y} y_m)^{1/p}$

Where γ is Euler's number (e^{y} = 1.781) constant

p = 3 (Zones) If the journals are ranked in decreasing order of productivity,

y_m = 376 (number of publications in the most productive journals).

$k = (1.781 * y_m)^{1/3} = (1.781*376)^{1/3} =$ **8.75**

Step 2:

$$Y_o = \frac{Total\ number\ of\ Publication\ (A)}{Number\ of\ Zones(p)}\ \frac{6897}{3} = \mathbf{2299}$$

Step 3: To find $r_{o,}\ r_{1,}\ r_2$ (number of journals in Bradford's core zone) $r_o = T\,(k\ -1)/\,(k^p\ -1)$

T = 772 (Total number of journals in Bradford zone)

$$k = 8.75,\ p = 3, \text{ therefore } r_o = \frac{772(8.75-1)}{8.75^3-1} = 8.94$$

$r_1 = r_0 * k$ = 8.94 X 8.75 = 78.23

$r_2 = r_0 * k^2$ = 8.94X $(8.75)^2$ = 684.47

Step 4: to find *a, b*

$a = Y_o = \log k = 2299/ \log 8.75 = 2416.59$

$b = k - 1/r_0 = 8.75-1/ 8.94 = 0.87$

Zone	Number of Journals	Journal %	Cumulative Publications	Cumulative Publications %
I (r_0)	9	1.16	1761	25.53
II (r_1)	78	10.10	2896	41.98
III(r_2)	685	88.74	2240	32.49
Total	772	100	6897	100

Table 2. Distribution of publications as per zones

According to Brookes (1979), to check the compliance of Bradford's regulation, the following three implied requirements should be met:

• The number of publications in each zone will remain constant if they are divided into three zones.

• Therefore the Bradford multiplier "*k*" should be greater than 1.

• "*k*" should be ideally consistent.

From Table 5.3, the number of journals in the zone-I is found to be $r_0 = 8.94$ and $k = 8.75$

$= 8.94:8.94*8.75:8.94*(8.75)^2$

$= 8.94:78.225:684.46875>771.63375$

$= 771.63375-772/772 \text{ X } 100 = 0.047$

Table 5.5.2 indicates that the number of journals in the Zone-I is 9 with 1761 publications, which is trailed by 538 articles deviating 23.40%. The second zone with 78 journals and 2896 publications, the number of articles exceeds 597 indicating a deviation of 25.96%. It could be noticed that in the third zone, the number of articles is short by 59 articles with a deviation of 2.56%. With such a vast deviation ranging from 23% to 26%, we cannot say the dataset follows Bradford's law even with Leimkuhler formulation. Bradford law clearly states the fact that each zone should have the same number of articles. A slight variation in the number of articles, say up to four or five per cent may be acceptable. The law never emphasizes Bradford multiplier for its verification. Since the equal multiplier is not a guarantee that the dataset follows Bradford law (Neelamma and Anandhahalli, 2016).

5.5.4. Graphical Representation of Bradford Law

As shown in Figure 5.4, the plot is a logarithmic graph of the total number of journals on the horizontal axis and, thus, of the total number of vertical axis publications. If the distribution fits the notion of Bradford, the graph known as the 'Bradford Bibliography' reveals the features of the three distinct areas. (1969 Brookes):

• Setting the pace for a rapid increase in the primary few stages,

• Display a significant part of the linear relationship connecting the two variables, and

• The 'sagging' at the end of the distribution indicates the inconsistency of the literature.

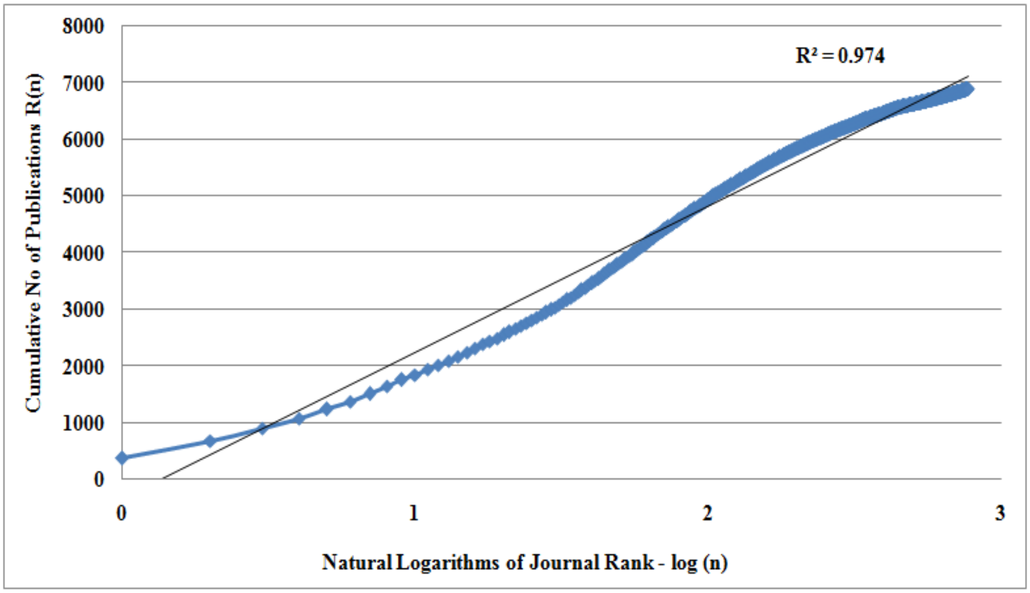

Figure 4. Observed relationship between cumulative articles and journal rank

The Bradford distribution with Groos droop is seen in Figure 5.5.4, where the journals are plotted against their efficiency. R2 is 0.974, which means that the linear relationship between the cumulative number of papers and thus the journal rank logarithm has largely been interpreted by 97.4 percent of the significant percentage within its cumulative amount of publications, leaving the gap of just 2.6 percent of the total variance within the cumulative number of items unresolved. Consequently, the relationship observed is almost on the verge of a graph between the total numbers of publications and hence the journal rank log. From the graph, it can be easily concluded that less journals contribute more publications and, as a result, in the linear portion of the graph, the largest number of journals is placed and ultimately reaches the top of the graph.

6. Conclusion

Robotic surgery is becoming more and more popular amongst the minimally invasive surgical centres, numerous hospitals already using this system or being in the process of implementing such protocols (Alexander et al 2018). Being performed on live animals just for experimental or training purposes at the moment, robotic surgery is still a field that exclusively defines human medicine (Gastrich et al., 2011). However, in this study, the journal distribution patterns in surgical robotics do not fit-Bradford's distribution pattern 1: n: n^2. In the present data set, a total of 772 journals and 6897 articles were scattered in three zones 16:64:692, which does not cover one-third of publication in each zone. Nevertheless, the approach based on the Leimkuhler model was used for the verification of Bradford's Law, where the journal articles were distributed at the following ratio of 9:78:685, even though the error percentage (0.047 %) was negligible, the Leimkuhler model still failed to comply with the law. This notion is to extend the scattering rule of Bradford to the Discipline of Surgical Robotics to classify the set of core papers. This awareness would be of benefit to researchers, fellows, and surgeons, fostering efforts to remain up-to-date in a world that is constantly evolving. Academic surgeons will also base their work in a structured manner on these articles.

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